BULLETIN

OF THE

Society for the Promotion of Engineering Education

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EDITORIAL.

The Bulletin as an Inter-college Newspaper.—The BULLETIN of the Society should be the medium of communication through which members are informed of progress in the several educational centers. Having no paid corps of news gatherers the BULLETIN must depend upon the co-operation of the members in gathering college news. If each member will cultivate the habit of sending in a note of any occurrence of sufficient importance to warrant printing it, the value of the paper is assured. News items are sent in from time to time by a few members, but many important events go unnoticed because attention is not called to them by members best qualified to describe them. The BULLETIN will be a success to exactly the extent to which the average member gives it his loyal support.

President Schurman's Report.—At the suggestion of Mr. W. D. Weaver, editor of the Electrical World, an extract from

the last annual report of the President of Cornell University is reprinted in this issue. President Schurman raises the question of the relation of research to the other functions of a University. All will agree that an institution in which productive scholarship is prominent will attract the most brilliant students and will graduate prospective leaders. At the present time it is probable that most of our technical colleges cater to the intellectual needs of the average student. This condition will probably always prevail, but there is a need for a few institutions which shall be fitted to do their best work for a few exceptional students.

APPLICANTS FOR ADMISSION.

BACON, E. W., Secretary, J. B. Lippincott Co., Philadelphia, Pa. ... 1911
DIETZ, J. W., Manager, Educational Department, Western Electric Co., 463 West St., New York, N. Y. ... 1911
GREMPLE, C. W., Instructor in Mechanical Drawing, University of Pennsylvania, Philadelphia, Pa. ... 1911
KIRBY, R. S., Professor of Civil Engineering, Pennsylvania College, Gettysburg, Pa. ... 1911
LARSON, G. L., Associate Professor of Mechanical Engineering, University of Idaho, Moscow, Idaho ... 1911
WALKER, B. M., Director of the Engineering School, and Professor of Mathematics, Mississippi A. and M. College, Agricultural College, Miss. ... 1911

COMMITTEE APPOINTMENTS.

President Raymond has appointed the following committees:

MEMBERSHIP COMMITTEE.

Dean John Galbraith, Toronto, Ontario; Prof. A. M. Greene, Troy, N. Y.; Prof. D. C. Jackson, Boston, Mass.; Prof. H. S. Jacoby, Ithaca, N. Y.; Prof. W. T. Magruder, Columbus, Ohio; Prof. C. F. Scott, New Haven, Conn.; Dean F. C. Shenehon, Minneapolis, Minn.; Dr. J. A. L. Waddell, Kansas City, Mo.; The Secretary, Chairman.

COMMITTEE ON ENTRANCE REQUIREMENTS.

Prof. J. J. Flather, Minneapolis, Minn., Chairman; Prof. L. P. Breckenridge, New Haven, Conn.; Dean J. P. Jackson, State College, Pa.; President F. W. McNair, Houghton, Mich.

LETTERS TO THE EDITOR.

SECRETARY S. P. E. E.,

Dear Sir: I send herewith a contribution to the BULLETIN. It was sent in the first instance to the editor of the *Engineering Record* with the understanding that it may also be available for publication in the BULLETIN.

Very truly yours,

ROBERT FLETCHER.

September 18, 1911.

TO THE EDITOR OF THE ENGINEERING RECORD.

Sir: Your excellent editorial on "Examinations," in *Engineering Record* of August 19, has a number of points of interest, and, since my first reading of it, it has been called again to my attention by a marked copy of the paper recently received. If you can spare the space I would like to make a few comments.

Undoubtedly examinations as frequently conducted have proven to be quite unsatisfactory tests of the real attainments and abilities of the students; for example, some of the examinations set by the Regents of the State of New York, some of whose papers are "fearfully and wonderfully made." The writer has long held the view that for the engineering student, at least, his text book and other reference books should be available at certain examinations. Papers may readily be so prepared that these helps will be of small use if the student is not well posted in his subject. The ill-informed student is sure to betray himself by some misuse of data or text, especially if he has slighted previous problems and class-room instruction. The writer, during the past few years, has conducted examinations as follows:

The entire class is assembled in the room to prepare a written paper which includes chiefly such problem work as you have described. Then in order to bring out the student's

grasp of definitions, fundamental principles, and essential concepts of the subject, another paper is prepared for oral examination. Three copies of this are provided, one for the examiner and two for the room where the examination is proceeding under supervision. When the work is well begun one student is called up, this paper is handed to him and he is directed to sit down in a place entirely apart from any helps and carefully look it over. The paper contains a series of questions relating to definitions and more important and even elementary principles and leading formulæ such as the man may be reasonably expected to have in mind. There may be fifteen to twenty-five such questions which the man should be able to answer in from five to seven minutes, talking without hesitation with ordinary rapidity. After the ten minutes allowed for considering his answers the man is sent down to the examiner with his paper in hand and the third paper is given to another young man with ten minutes for consideration. The examiner then hears the man recite his answers to the questions on the paper, usually without making any remarks, unless it be to draw out, here and there, the student's understanding of the subject. At the expiration of an allotted time, say seven to nine minutes, the student is dismissed, whether or not he has completed the series of replies, and another student is sent down while the first one returns to his written work and hands his paper to the proctor to serve for the third man. In this way the grasp which a student has of some of the most essential points is well tested, for on these he has no access to his books and has simply time enough to arrange his ideas on the questions proposed; also the questions are the same for each one, and the examiner himself is not burdened with the task of repeating them; his part being only to listen and check off on a roster list the valuation of each answer.

In an experience of nearly forty years as an instructor in mathematics and civil engineering the writer has always held that a part, at least, of every examination should consist of a

series of questions "fired" rapidly at the students, to be answered quickly, so that the readiness of the student in his answers is one test of his proficiency.

It is in order to remark that while the method by problems is good in principle it may be entirely overdone. Too much of the instruction, for instance, in our high schools is conducted by the medium of an excessive number of "examples" and problems, and not enough emphasis is put upon compelling the student to acquire facility in the statement of definitions and principles. In other words, the writer has found that very few students get clear-cut conceptions of many of the fundamentals of the studies which they pursue. Solution of problems does not give this ability. It is useless to suppose that a student has a vital knowledge of a subject if he does not fully understand what he is talking about.

It is proper to remark that this method has been applied to classes of from ten to twenty-five, which in some institutions would be small. Moreover all subjects are pursued continuously to a finish, with usually not more than *two tests* by examination, viz., one at about the mid period and one as a conclusion. Regularity of attendance being required, each man is tested day by day, and his progress and proficiency fairly well determined thereby.

The writer has some definite ideas on other aspects of this question, but as your space is limited he will spare your readers further infliction.

Very truly yours,

ROBERT FLETCHER,
Director of Thayer School of Civil Engineering, Dartmouth College.

EDITORIAL ROOMS, ELECTRICAL WORLD,
239 West 39th Street, New York.

My dear Prof. Norris: As I wrote to you previously, I have been surprised to find that several professors of electrical engineering to whom I spoke of President Schurman's report, with particular reference to the section on college organiza-

tion for research work, knew nothing of this important contribution to a great subject. In view of this situation, would it not be advisable to reprint that part of the report in the BULLETIN OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION?

Sincerely yours,
W. D. WEAVER.

September 26, 1911.

In response to Mr. Weaver's suggestion, an extract from the above-mentioned report is reprinted with Dr. Schurman's permission. The report was the annual one for 1909–1910 made in November, 1910.—ED.

SECRETARY S. P. E. E.,

Dear Sir: There is one feature of engineering education which may, or may not have received attention by the Society which my experience in twenty-five years in the business of producing and distributing electricity has brought forcibly to my attention, and that is that it would be very desirable to so educate electrical engineers that they would after graduation have enough of the understanding of the commercial end of the electricity supply business and what it offers to young men to seriously consider taking up such employment. My experience is that the really bright and able men in the commercial end of the business get ahead much faster and earn more money than the men in the technical end, notwithstanding that the technical men have a much better equipment. Most of the technical graduates which come under my observation rather sneer at the commercial end until after they have put in anywhere from five to fifteen years of rather unproductive grind, when after having lost many fine opportunities, they in many instances awake to the fact that they should have followed the commercial end of the business, and with their technical education would have made a very great success of it.

Very truly yours,
JOHN F. GILCHRIST.

Mr. Gilchrist is president of the great National Electric Light Association and is in a position to know from observation the weak points in a technical education from the business man's standpoint.—ED.

SECRETARY S. P. E. E.,

Dear Sir: Some time ago there was printed in *Science** an article suggesting improvements in our present methods of framing examination questions. I send you an examination question, which is based on one of the suggestions in the above article. The student is supposed to fill in the blanks, and the mark is simply the ratio of the blanks correctly filled to the total number of blanks. The plan proved very satisfactory.

Very truly yours,

V. KARAPETOFF.

CORNELL UNIVERSITY.

Commutation.—In the coil of a d.c. armature the current is reversed during the interval of time when the coil is short-circuited by a set of brushes. Let b be the width of the brush, m the thickness of insulation between the commutator segments, both in millimeters; let v be the peripheral speed of the commutator in meters per second. Then the time of short-circuit is seconds. Assume first that the armature coils have no inductance; the current is then reversed according to the law, because it is solely determined by the of the brush. This is proportional to the surface of the contact with the individual segments, so that the current under all parts of the brush is . Under these conditions the commutation is perfect and sparkless. In reality the armature coils possess an appreciable due to in the slots and around the . This acts like inertia

* See in *Science*, Vol. XXXIII, p. 661, Apr. 28, 1911, an article by Professor Max Meyer.

and the reversal of the current. Therefore, the current under one edge of the brush decreases more than the area of the contact. The current density at this edge creases and after a certain limit has been reached glowing and sparking result.

Editor S. P. E. E. BULLETIN,

Dear Sir: Please note the following typographical corrections in my article on Elementary Dynamics printed in the October issue.

Yours truly,
WM. KENT.

P. 70, 8th line from bottom, for 1910 read 1909.
3rd line from bottom, for Oct. 29 read Dec. 24.
P. 72, 6th line from bottom, insert S before $=$.
P. 73, middle of page, for F/a read F/A.
4th line from bottom, for "indirectly" read "inversely."
6th line from bottom, for Ws read W's.
15th line from bottom, drop colon and insert semicolon and space.
P. 74, 15th line, for "at height" read "at that height."
P. 74, 17th line, for $\sqrt{2}gs$ read $\sqrt{2gs}$.

PROFESSOR EDWARD L. HANCOCK.

I am writing to inform you of the recent death of Professor Edward L. Hancock, Professor of Applied Mechanics in the Worcester Polytechnic Institute, who was an active member of your society. Professor Hancock died October first, of sarcoma, after a comparatively short illness. He leaves a widow but no children.

Professor Hancock was rated by us as an exceptionally strong man, and his loss is severely felt. I am sending this to you for official notice to your Society. I should add that he was a graduate of the University of Wisconsin, and was formerly Professor of Applied Mechanics at Purdue University.

Very truly yours,
LEVI L. CONANT,
Acting President.

MR. J. A. VEAZEY.

Mr. J. A. Veazey, one of the new members of the Society, who was a graduate student in Cornell University last year died on August 21, 1911, of typhoid fever after an illness of but two weeks. Mr. Veazey graduated from Westminster College in June, 1902, since which time he has been an instructor in physics and astronomy at Assiut College, Assiut, Egypt (1902–1905), a graduate student in mathematics and physics at Cornell University (1905–1907), and instructor at Lehigh University (1907–1909) and a fellow in physics in Cornell for the past two years.

COLLEGE NEWS.

Colorado Agricultural College.—The annual field camp for the students in the civil and irrigation engineering course was held August 22 to September 5 at the Ft. Lewis School, 14 miles northwest of Durango, Colo. A party of twenty students was in camp for a period of two weeks. The work consisted in making a survey for the irrigation system of the reserve, which consists of 6,000 acres. Two small storage reservoirs were surveyed, taking the topography to obtain the capacity of each with inlet and outlet ditches. The cultivated fields were surveyed to determine the acreage. Boundary lines were determined to establish the corners of the reserve. The work was of such a varied nature as to give the students practice in surveys for the purpose of filing claims for water-rights with the state engineer of Colorado.

Cornell University.—Professor O. M. Leland, of the department of astronomy and geodesy in Cornell University, has been requested by the Chief Justice of the United States Supreme Court to serve as a member of a commission of four civil engineers in the arbitration of the boundary dispute between the republics of Panama and Costa Rica. Two of the commissioners will be the representatives of the two countries, while the other two, selected by the Chief Justice, to whom the matter was referred, will be impartial, disinterested engineers. Director J. F. Hayford (Cornell, '89), of Northwestern University, will also be a member of the commission.—The Rand Shops Building, now being erected for Sibley College, is well under way. It will be ready for use in the spring. The pattern shop will occupy the third floor, the machine shop the first floor, and, pending the erection of a new electrical laboratory, for which it is hoped that funds will soon be provided, the advanced electrical engineering laboratory will be located on the second floor. The building is 169 feet by 50 feet, with wing about 40 feet square.

Harvard University.—In 1911–12 the Graduate School of Applied Science of Harvard University will offer courses in sanitary engineering. This new department will be in charge of Professor George C. Whipple, Mr. J. W. M. Bunker and Mr. M. C. Whipple. A complete chemical and biological laboratory for the analysis of air, water, and sewage has been installed, with special equipment for studying the principles of water purification, steam pollution and sewage disposal, the disposal of wastes, etc. Opportunities will be provided for special research in the field and at plants in actual operation. The work outlined is intended primarily for graduate students in civil engineering, but courses are to be arranged for students of the Medical School who are candidates for the degree of Doctor of Public Health, and for university students who desire to take up in a general way the subject of municipal sanitation. Special arrangements will be made also for research work by properly qualified students in water analysis, sewage disposal, purification of trade wastes, sanitary design, etc.

University of Illinois.—The registration of students in the College of Engineering during the first two days totaled 1,135. Among the new appointees in the College of Engineering and the Engineering Experiment Station for the academic year 1911–1912 are the following: C. R. Richards, B.M.E., Purdue University, 1890, M.E., 1891, M.M.E., Cornell University, 1895, for nineteen years associated with the engineering work of the University of Nebraska and for several years as professor of mechanical engineering and dean of the College of Engineering, has been appointed professor of mechanical engineering in charge of the department.—A. M. Buck, M.E., Cornell University, 1904, for two years assistant professor of electrical engineering at New Hampshire College, and for the past year professor of electrical engineering at the Clarkson School of Technology, has been appointed assistant professor of railway electrical engineering.—F. C. Lincoln, S.B., Massachusetts Institute of Technology, 1900, E.M., New Mexico

School of Mines, 1904, A.M., Columbia University, 1906, Ph.D., 1911; for three years professor of geology and metallurgy at the New Mexico School of Mines, for three years professor of geology at the Montana State School of Mines, and for the past year in practise in New York City as consulting mining engineer, has been appointed associate in mining engineering.—Paul Hanson, B.S., Massachusetts Institute of Technology, 1903; for several years practising sanitary engineer, expert of the Massachusetts State Board of Health, chief engineer of the Ohio State Board of Health, and for some time past State Sanitary Engineer of Kentucky, has been appointed associate in sanitary engineering.

The following promotions, affecting older members of the staff of the College of Engineering, were authorized by the board of trustees to become effective September 1, 1911: G. A. Goodenough from associate professor of mechanical engineering to professor of thermodynamics.—M. L. Enger from associate in theoretical and applied mechanics to assistant professor of theoretical and applied mechanics.—J. E. Smith from instructor in civil engineering to associate in civil engineering.—V. R. Fleming from instructor in theoretical and applied mechanics to associate in theoretical and applied mechanics.—H. W. Miller from instructor in general engineering drawing to associate in general engineering drawing.—F. S. Foote, Jr., from instructor in railway civil engineering to associate in railway civil engineering.—I. W. Fisk from assistant in electrical engineering to instructor in electrical engineering.

State University of Iowa.—Professor Arthur G. Smith has been transferred from the department of mechanics in the College of Applied Science to the headship of the department of mathematics in the College of Liberal Arts made vacant by the resignation of Professor L. G. Weld.—Professor Sherman M. Woodward has been made professor and head of the department of mechanics in the College of Applied Science, being in responsible charge of theoretical mechanics, hydraul-

ics and engineering materials.—Mr. John H. Dunlap has been promoted from instructor in civil engineering to assistant professor of hydraulics and sanitary engineering.—Mr. Ralph S. Wilbur, B.S. in M.E., 1908, Tufts College, has been appointed instructor in steam engineering in place of Mr. John E. Boynton who goes to Lafayette College.—Mr. Robert M. Black, A.B. Harvard, 1910, E.M. Michigan College of Mines, 1903, and Mr. Henry B. Smith, C.E. University of Virginia, 1909, have been appointed instructors in civil engineering and mechanics.—Mr. Edwin A. Dow, Sc.B. in C. E. Brown, 1911, has been appointed instructor in descriptive geometry and drawing in place of Mr. Roland E. Hutchins, who goes to Brown University.—Mr. B. F. Zimmerman has been appointed superintendent of shops in place of Mr. Harold W. Smith, who assumes the principalship of a boys' high school in Burma, India.

State University of Kentucky.—Mr. William Edwin Freeman, of New York, for seven years connected with the Western Electric Company, has been elected to the professorship of electrical engineering, State University of Kentucky, made vacant by the resignation of Professor A. M. Wilson.—In the electrical engineering laboratories at the State University of Kentucky there is being conducted at present a series of tests on locomotive electric headlights for the Q. and C. road.—Professors Anderson and Frankel have been appointed by the board of trustees to design and superintend the erection of a $60,000 addition to the Kentucky Agricultural Experiment Station.—In the College of Mechanical and Electrical Engineering, State University of Kentucky, a good deal of interest is being taken in the student branches of the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. The students are furnished with the journals of these two societies, and the meeting consists of a review of the papers presented for these societies.

University of Minnesota.—The splendid, large mechanical engineering laboratory of the University of Minnesota is completed and its use for teaching purposes has already begun.—

The main engineering building of the university is rapidly approaching completion. It will probably not be fully equipped and ready for use before the beginning of the first semester of 1912–1913, next fall.—Dr. Arthur E. Haynes, who was granted leave of absence last year, on account of ill health, has resumed his work of teaching engineering mathematics. After a complete rest in California and elsewhere, he returns fully restored in health, to resume the work in which he had been engaged for forty years.

Ohio State University.—Professor L. W. McOmber has resigned to go into practical work.—Mr. A. H. Heitmann has been promoted to the rank of instructor, and Mr. James Mainland, a graduate of the University of Wisconsin, has been appointed as an assistant.—Professor Caldwell, who has been away on leave of absence during the past two years on account of ill health, has returned, much improved.—A graduate school has recently been organized at the University which will place the giving of advanced degrees in engineering lines, upon a substantial basis.

University of Pittsburgh.—The School of Engineering at the University of Pittsburgh opened on September 25 with a very much increased attendance, the freshman class numbering four times as many students as that of two years ago. The coöperative system has proven very satisfactory in every way, and has received the hearty coöperation of the manufacturers. The increased enrollment has necessitated the immediate enlargement of the buildings and equipment provided for this school, the principal extensions being in freshman chemistry laboratory and forge and foundry shops.

Purdue University.—Purdue University shows this autumn an increased rate of growth after a comparatively stationary population for the last few years, the freshman class this year being larger than usual.—Professor H. C. Peffer has been appointed professor of chemical engineering and has just assumed his new duties. The School of Chemical Engineering

has shown a healthy growth since its inception four years ago, the freshman class last year numbering 32 as against the senior class of 10 students. There is a considerable demand for men who are capable of managing both the engineering and the chemical features of a manufacturing business.—The rapid growth of the agricultural side of the institution is one of the noticeable features at present. There is a decided awakening on the part of the agricultural people of the state as regards the scientific aspects of farming.—The new hydraulic laboratory at the university has just been put in commission and promises to be a great addition to the resources of the engineering schools for both educational and experimental work.—Professors L. D. Rowell and A. D. Dubois have come from Case School of Applied Science and Cornell University, respectively, to the School of Electrical Engineering.—In the School of Mechanical Engineering, there have been several changes: Professor L. V. Ludy is on a year's leave of absence at the University of Wisconsin; Professor J. D. Hoffman has resigned to take the chair of Mechanical Engineering at Nebraska; Professor G. A. Young is acting head of the school this year; Messrs. O. C. Berry and E. A. Herrcke have been added to the instructional corps.—Considerable interest is displayed on the subject of aviation. Two machines of different types have been loaned the university for experimental purposes.

Stevens Institute of Technology.—Professor J. E. Denton, after thirty-six years of active teaching, has retired from the chair of engineering practice. He will spend his entire time hereafter in his expert work, having found that his health will not permit him to carry the double load of teaching and practice. Professor W. T. Magruder, who is on a leave of absence from Ohio State University, is taking Professor Denton's place for a few weeks. Professor Magruder does this at the request of his class-mate, President Humphreys (Stevens, '81).

Tulane University of Louisiana.—A reorganization has recently been effected by which the former Academic Colleges

now become separately the College of Arts and Sciences and the College of Technology, each under a separate dean. Professor W. H. P. Creighton, professor of mechanical engineering, has been chosen as the dean of the college of Technology.—A new building is in process of erection for the College of Technology which will provide more adequate quarters for several departments which are badly crowded. The building is to be 138 by 60 feet in dimensions and three stories. The ground floor will be used principally for the laboratories of the department of electrical engineering, the second floor will provide lecture rooms and offices for four professors as well as a room to be used for a departmental library, and the third floor will be used for drawing rooms, the larger portion of it being given over to the department of architecture. This building is being erected with the proceeds of a bequest of $60,000 left the university by Mr. Stanley O. Thomas, a prominent business man of this community.—Professor S. J. Barnett has resigned his position as professor of physics to accept a position in the physics department at the University of Ohio. He has been succeeded here by Dr. J. H. Clo, of the University of Chicago.

Sheffield Scientific School, Yale University.—The new Mason Laboratory of Mechanical Engineering will be completed about November 1.—Mr. Chas. F. Scott, consulting engineer of the Westinghouse Electric and Manufacturing Company, has taken up his new work as the head of the recently established department of electrical engineering.

Wentworth Institute, Boston Mass.—The new Wentworth Institute, a school to train men for efficiency in industrial work, has just opened in Boston. Its enrollment of all-day students is over two hundred (200), which is really more than its present capacity, and many applicants had to be turned away. The applications for evening work total nearly 1,000, which is far more than can be admitted. The material is very promising, and with its magnificent shops and laboratories, the institute will fulfill the needs of this kind of instruction

which the tremendous list of applications shows to have existed.

University of West Virginia.—Mr. Roland P. Davis has been elected an associate professor in charge of the department of civil engineering in the University of West Virginia, succeeding Professor Wm. Hagen Boughton, who has become the treasurer and general manager of Vassar College. Professor Davis was formerly an instructor in the department of bridge engineering in Cornell University.

THE PROBLEM OF RESEARCH.*

BY JACOB GOULD SCHURMAN,
President of Cornell University.

The future of the American university is with the graduate school or department of research. It is by the enlargement of human knowledge that progress in civilization and improvements in the life and condition of mankind are rendered possible. The scientific investigator who discovers new laws of nature does more for the relief, assistance and uplifting of his fellow-men than all the politicians who deafen the world's ear with their panaceas—too often, alas, mere sounding brass and tinkling cymbals. And the infallible lessons of human experience for thousands of years—does not the scholar by patient research spell them out and write them down for our instruction? These two—the scientist with his fruitful experiments, the scholar with his productive research—are the seers and accredited leaders of mankind in this twentieth century. In their light we shall see light, otherwise we walk in darkness. And it is such scientists and scholars who constitute the research department of the university.

This crowning glory of the university is not yet a fact in America; it is only an expectation, or at most a promise. When the realization comes—and come it certainly will, at Cornell or elsewhere—it will mark the final and culminating stage in the development of the university idea. At present the graduate schools of American universities have not been so much departments of research as colleges for the advanced training of prospective teachers and professors. Here and there a university or a department has risen above this routine and recognized its call to make explorations beyond the verge of existing knowledge. But little has been accomplished for

* Eighteenth Annual Report of President Schurman to the Board of Trustees of Cornell University for the year 1909–10.

two reasons. First, the investigator is burdened with teaching students and comes jaded and distracted to the task of research, which in a superlative degree calls for a mind in the freshness and plenitude of its powers. And secondly, while a great graduate school and division of research really needs as much money as the present total endowment of the richest of American universities, the investigator to-day finds available for research only such driblets of funds as are appropriated to his department primarily for the purpose of instructing students. Both evils could be remedied by special endowments for research.

Here is the multi-millionaire's opportunity for the greatest and best investment in America! By means of a large endowment for research (say $20,000,000, which might be given at once or spread over a period of years) he would make it possible for at least one American university to enter upon the highest stage of university life and activity and to discharge its supreme function to the American public and human civilization. A university dedicated by such an endowment to advanced work and research would challenge comparison with the best European universities and set an example which would prove contagious among the other leading universities of the United States.

It is essential to the success of the enterprise that productive scholarship and scientific investigation shall have as organ a genuine university. The alternative is either a corporation holding funds which it doles out in such ways for such purposes to such investigators and in such places as its managers deem expedient, or a truncated institution called a university which consists only of professors and graduate students. Johns Hopkins University has renounced the latter character and taken on a college of arts and sciences for undergraduates; and so has Clark University; and in view of their experience, no other institution is likely to essay occupying the ground which they have abandoned. Experience has also demonstrated insuperable objections to the plan of conducting research by agreement or contract between the investigator

and a more or less foreign corporation chartered for the sake of holding funds. The true place for research is in the university; for the essential members of the university are professors and students. The men who conduct the investigations are themselves, to all intents and purposes, the very organization which also controls the funds. The work of these men is the very object and function of the institution. That work in its highest form is research and productive scholarship.

A VISIT TO THE WESTINGHOUSE WORKS AFTER THE PITTSBURGH MEETING.

BY PROFESSOR G. B. THOMAS.

The Westinghouse Electric and Manufacturing Company extended a special invitation to the members of the Society for the Promotion of Engineering Education to visit their works at East Pittsburgh on Friday and Saturday, June 30 and July 1, following the regular session of the convention in Pittsburgh. Most of the forenoon of Friday was spent in inspecting parts of the Westinghouse Electric and Manufacturing Company's works and in listening to talks by the company's engineers on the most recent developments in electrical machinery. Just before noon the party was conducted to the works of the Westinghouse Machine Company where, after a short inspection, lunch was served by the Machine Company in their dining room. After lunch some time was spent in the Machine Company's works and then the party was conducted to the Westinghouse Electric and Manufacturing Company's works again, where further inspections were supplemented by talks.

Dinner was served in the evening in the officials' dining room, at which the officials and engineers of the Westinghouse Electric and Manufacturing Company were the hosts. After dinner, talks were made by some of the company's representatives and by some of the visiting professors; the general sentiment expressed was of good will and a wish for closer coöperation between the company and educational institutions.

On Friday evening, a special program was arranged at the Westinghouse Club in honor of the visit of the college professors. The performances were enjoyed and the visitors seemed happy moving about and meeting with old friends and former students. The visitors were: Messrs. Bishop, of the University of Pittsburgh; Borger, Duncan and Paine, of

the University of Illinois; Brown, of the University of Texas; Browning, of the University of Kentucky; Buck, of Clarkson; Burpee, of Bucknell; Charters, of Leland Stanford; Ewing, of Ohio Northern; Lawton, of Dennison; Morse, of Kansas; Morse, of Michigan Agricultural College; Rhodes, of the University of North Dakota; Sage, of the Agricultural and Mechanics College of New Mexico; Schuerman, of Vanderbilt; Thomas, of Colorado College; and Work, of Carnegie Tech.

On Saturday only a few of the professors took advantage of the company's invitation and these were conducted to the special section in which they were interested and given liberty to proceed as they desired.

Together with the invitation to visit the works on Friday and Saturday, the Westinghouse Electric and Manufacturing Company announced that there would be an opportunity for several of the college instructors to arrange to spend the summer in the various tests. On investigating the Educational Department of the Company found that eighteen college instructors, coming from fourteen different states, were at the works for a part of the summer. The Educational Department then called a meeting of these men at the Westinghouse Club for Thursday evening, July 13, for the purpose of ascertaining if anything further could be done to increase the value of the summer's stay. A general discussion crystallized into the sentiment that a few detail inspection trips followed by a talk by one of the engineers of the section visited, would be of much value.

Accordingly, seven of these special inspection trips were arranged for by the Educational Department. The kinds of apparatus taken up were transformers, direct current industrial motors, synchronous machinery, induction motors, railway motors and locomotives, turbo-generators, and motor-generator sets and rotary converters. An hour and a half were spent in the shop with a guide and an hour was set aside for the talk on the special line of machinery and the present problems to be solved; following the talks an opportunity was given the instructors to ask questions. These meetings proved

very valuable, giving instruction in the present types of machines being manufactured, their method of manufacture, the problems met in the construction, the history of the development, and the present problems being considered in the betterment of the design. The instructors were so pleased with the plan and the way it worked out that the company is considering taking up the matter more thoroughly next summer and arranging for each department of electrical engineering, that so wishes, to send one of its men to East Pittsburgh during the summer, where, in addition to the opportunity of working in the shops, there will be given a dozen or so special detail inspection trips, followed by talks. It is to be hoped that it can be arranged, as the touch with the commercial end of electrical engineering will vitalize the courses in the colleges.

HIGHER EFFICIENCY IN TECHNICAL EDUCATION.

Extracts from Sir William Ramsay's Presidential Address before the British Association for the Advancement of Science.

In England we have made technical education a local, not an imperial question; instead of half a dozen first-rate institutions of university rank, we have a hundred, in which the institutions are necessarily understaffed, in which the staffs are mostly overworked and underpaid; and the training given is that not for captains of industry, but for workmen and foremen. "Efficient captains cannot be replaced by a large number of fairly good corporals." Moreover, to induce scholars to enter these institutions, they are bribed by scholarships, a form of pauperization practically unknown in every country but our own; and to crown the edifice, we test results by examinations of a kind not adapted to gauge originality and character (if, indeed, these can ever be tested by examination), instead of, as on the Continet and in America, trusting the teachers to form an honest estimate of the capacity and ability of each student, and awarding honors accordingly.

The remedy lies in our own hands. Let me suggest that we exact from all gainers of university scholarships an undertaking that, if and when circumstances permit, they will repay the sum which they have received as a scholarship, bursary, or fellowship. It would then be possible for an insurance company to advance a sum representing the capital value, viz., £7,464,931, of the scholarships, reserving, say, twenty per cent. for non-payment, the result of mishap or death. In this way a sum of over six million pounds, of which the interest is now expended on scholarships, would be available for university purposes. This is about one fourth of the sum of twenty-four millions stated by Sir Norman Lockyer at the Southport meeting as necessary to place our university education on a

satisfactory basis. A large part of the income of this sum should be spent in increasing the emoluments of the chairs; for, unless the income of a professor is made in some degree commensurate with the earnings of a professional man who has succeeded in his profession, it is idle to suppose that the best brains will be attracted to the teaching profession. And it follows that unless the teachers occupy the first rank, the pupils will not be stimulated as they ought to be.

Again, having made the profession of a teacher so lucrative as to tempt the best intellects in the country to enter it, it is clear that such men are alone capable of testing their pupils. The modern system of "external examinations," known only in this country, and answerable for much of its lethargy, would disappear; schools of thought would arise in all subjects, and the intellectual as well as the industrial prosperity of our nation would be assured. As things are, can we wonder that as a nation we are not scientific?

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ADAPTING TECHNICAL GRADUATES TO THE INDUSTRIES.

BY C. F. SCOTT AND C. R. DOOLEY,

Pittsburgh, Pa.

The Westinghouse Electric and Manufacturing Company has recently modified its two-year course for technical graduates* principally by supplementing factory and testing-room experience with class-room instruction and by specializing the training in the latter part of the course, adapting it to the particular work which is to be followed later. The present paper outlines the conditions and the reasons which have led to the change and describes the general methods which are being followed.

A large step in engineering education was taken ten or fifteen years ago when it was recognized by the industries

* In addition to the course for technical graduates, the following educational activities are carried on in connection with the Westinghouse Electric and Manufacturing Company, at East Pittsburgh, Pa.

1. A Trades Apprenticeship Course in which boys with ordinary public school training enter a four-year course, the purpose of which is to train them as skilled mechanics. They enter an instruction shop and are afterwards transferred to the regular departments where they are still under the supervision of the educational department. Each apprentice attends a drawing class two hours per week, and a class for general instruction, which deals with shop problems and elementary mechanics, for two hours a week. This instruction is given during regular working hours and the regular rates of compensation are paid. There are 214 apprentices in this course at present.

2. The Casino Technical Night School, having a regular four-year course. School sessions are held three evenings per week from September to June. The majority of the students come from the works of the Electric Company, although attendance is open to any one. A small tuition fee is charged. The teachers are principally engineers most of whom are connected with the Electric Company. There is also a department for young women. The enrollment last year was approximately 500, and there are about 40 in the faculty.

that the education of the engineering schools should be followed by specific practical training, and suitable shop courses were inaugurated for bringing young graduates into active contact with the apparatus and the methods of manufacture. For many years the Electric Company has received annually several hundred graduates. They have been regularly employed in factory, testing room, engineering department, and the various commercial departments.

In this graduate student course the men were formerly transferred from department to department and were expected by contact with their work, to acquire a knowledge of the construction and use of electrical apparatus and of business methods. Supplementing the regular daily work, an evening lecture course was conducted during one season ten years ago. This was followed by the organization of a club with facilities for lectures, technical meetings and social activities. However, little was done in the way of systematic instruction bearing directly upon factory and office work. While much can be said in favor of a " sink or swim " policy and the value of learning things by personal observation and experience, the conclusion has been reached that better results, on the whole, will follow a modification of this former method, which is open to improvement for several reasons:

1. Electrical apparatus is now of so many kinds and has become so specialized that ordinary shop work is no longer a sufficient means of instruction. Furthermore, a fuller knowledge concerning the details of construction and the principles of operation is now essential to the designing engineer and the application engineer than was formerly necessary.

2. Factory work by a beginner is apt to be inefficient from the standpoint of the employer and the ordinary young man has difficulty in observing and in learning what he should do. The transition from the prescribed lessons and personal supervision of the school life is too abrupt.

3. The point of view is apt to be that of the workman who knows only of the construction of the coil he winds, or the arc lamp he assembles, without appreciating why the appara-

tus is made as it is, in order that it may be reliable, durable and efficient. He may learn what it is without learning why; he may miss entirely the ideas of the electrical and mechanical designers which are embodied.

4. The time available in the factory is too short to enable one to cover the whole ground thoroughly, hence factory experience is ordinarily limited to a few departments and a few kinds of apparatus. The course must cover but few departments if it is to be thorough, while if it endeavors to cover all departments uniformly and comprehensively, it becomes too superficial.

To meet these modern conditions, a new method of training has been inaugurated for the graduates who are now entering the course. The following presents a general outline of the plan and policy which have been carried out:

1. The course is divided into two periods. The first is given to general training in the factory and testing department, while the second, is special, fitting men for the engineering, sales or other departments.

2. In the first period, the work in the factory and testing room is, in the main, confined to a few departments, where the essentials of winding, assembling and testing occupy most of the time and in which a reasonable degree of proficiency is required. Each man enters one of the general departments of the factory; such as the railway and control departments, where railway motors, locomotives and controllers are made; or the industrial department, where small motors and controllers are produced; or the power department, where large generators and motors are manufactured. Each of these departments is essentially an independent factory, carrying on complete manufacturing and testing operations.

3. Supplementing the factory organization, there are supervisors who assist the foremen in making the work of the graduates effective in the regular manufacture of the company's product, and at the same time aid the young men in acquiring useful knowledge and experience. The shop work is of a practical, serious sort in which the young men learn

to be workers and producers and develop a sense of service and of vital responsibility.

4. Supplementing the work in the factory and testing department, a course of technical instruction has been started which comprises attendance at class-room meetings during working hours, for approximately four hours per week, during which time the regular rates of compensation are paid. Also the equivalent of at least six hours per week outside of the regular working hours, is required to be devoted to assigned reading, study or technical meetings. This technical instruction relates particularly to the construction and operation of the apparatus and it directly supplements the work in the factory. It is proposed that the men who are working on a particular kind of apparatus will have an instruction period devoted to it each week. Instruction books or appropriate articles may be assigned for reading, a list of questions may be given to the students beforehand, and in the class-room there may be questions, general discussion or talks by the company's experts. For example, on a certain day those who are winding coils, will meet in the class-room and under the guidance of an instructor, will consider the types and forms of coils, the various methods of forming odd-shaped coils, the characteristics of the insulating materials and methods of applying them, the insulation required on coils of different sizes and for different purposes, the methods of splicing wires and copper strap, the machine-winding and hand-winding of coils, also the cost of the materials and labor. The more purely engineering features, as the ventilation, carrying capacity, eddy currents and the like, will receive only secondary consideration at this time.

5. General instruction regarding the various types of apparatus supplements that relating specifically to the factory or testing room work upon which the men are immediately engaged. Thus, comprehensive acquaintance with all types of apparatus is gained through reading, discussions and lectures, accompanied by visits of inspection to the various departments of the works. The young men will be called

upon to observe for themselves, and to make written and oral reports. For this purpose evening meetings are held.

6. At the beginning of the second period of the course, the young men take up the special training for the engineering, sales or other departments. The experience in the first period places both the young men and the company in a position to make an intelligent selection of the departments for which they are best fitted.

7. The several departments have direct supervision of their respective training courses. In some cases the work continues in the factory and the testing department along particular assigned lines. In other cases, regular work, under proper supervision, is done in the engineering, sales or other departments, while, in still other cases, a portion or all of the time may be devoted to special study and class room exercises.

8. The sales department has been conducting, during the past year and a half, a commercial training department for the engineering graduates who are completing their courses and are to become salesmen. These young men study the company's publications; they answer specially prepared questions on the construction and application of the various kinds of apparatus; they give special attention to the engineering and commercial features in the application and use of electric motors as applied to different industries; they become familiar with the details of the system by which the company conducts its business; and they make a study of scientific salesmanship. Part of this work is under special instructors, and part is under the supervision of leaders selected from the class. In the study of apparatus, frequent trips are made to the factory and smaller apparatus is brought to the class-room. Sales demonstrations in which students endeavor to sell arc lamps, meters, or motors to other students or to engineers or salesmen, are fruitful methods of testing a man's technical knowledge, his resourcefulness and the force of his personality. At the close there is review and criticism by the class and the experts.

9. The engineering department is actively maturing plans

for training men for its work which will combine experience in factory and in the engineering department in a way most effectively to train men as designing engineers.

10. In addition to the above, during the second period, particular courses will also fit men for the manufacturing, the testing and the erecting departments.

11. The instructors who have immediate charge of the various departments of the training course are specially fitted by education, experience and temperament. Most of them are technical graduates, who have taken the apprenticeship course and have had several years of practical work. They have at hand for guidance and counsel the various officers and engineers of the company and, when needed, they can call upon them and the experts and specialists in various departments for assistance in the educational work which they are directing. This will bring the new men into contact with the older men of the company.

12. The Westinghouse Club, formerly The Electric Club, which has just closed its first year in new quarters continues to contribute to the welfare of the graduate students. During the past year there has been a weekly course of high grade lectures on general topics. There have been seventeen technical sections, each meeting every two weeks, and each dealing with some type of apparatus or its application or some phase of the company's organization. The older engineers have taken an active part in these meetings. Excursions by the young men in a number of groups have been made to a score of industries in and about Pittsburgh.

The club provides a convenient social headquarters for the young men. There are a dozen rooms for reading, writing, general gatherings and amusements, as well as lectures and formal meetings. There is also a large and well equipped gymnasium which contributes to the physical welfare and athletic enthusiasm of the members. The dues, for those on the graduate course, including the gymnasium and *The Electric Journal,* published monthly by the club, are $7 per year.

The club activities are managed by young men who find this an excellent means of getting into close contact with their fellows and of showing their aptitude for organization and management.

13. Underlying the purely technical knowledge and experience which nominally form the principal content of the training course, there is the even more important purpose of developing men. As the electrical industry increases and more exacting requirements are placed upon electrical apparatus, which is taking a larger and more responsible part in the doing of the world's work, there is demand for greater ability on the part of the engineers and managers who have to do with the production and operation of apparatus and the direction and management of manufacturing and operating companies. Many of those who now hold responsible positions in the various departments of such companies or as consulting engineers, have gained an important part of their experience in the training courses of manufacturing companies. It is the aim in the plans which have been outlined in this paper to keep pace with the new conditions and to prepare men for the larger duties and larger responsibilities which they will face in the future as engineers and as men.

THE COOPERATIVE SYSTEM OF ENGINEERING EDUCATION AT THE UNIVERSITY OF PITTSBURGH.

BY F. L. BISHOP,

Dean of the School of Engineering, University of Pittsburgh.

An educational institution resembles, in some respects, a manufacturing concern. The manufacturing concern is, however, usually operated to produce a maximum output at a minimum cost, while the educational institution should aim for a small number of exceptional graduates almost irrespective of cost. The goods produced must be of such design, finish, material, etc., as to satisfy its patrons; likewise, the graduates of educational institutions must meet the requirements of the concerns which are to employ them. The undesirability of the output of a factory may be caused by poor material, poor workmanship or poor design. The cost may be greatly enhanced by antiquated methods of production. The inefficiency of a graduate (and I apply the word "inefficiency" to include all the undesirable characteristics) may be caused by poor material, due largely to improper preparation of the student at entrance to the college or to poor instruction, poor teachers or antiquated and improperly-correlated courses.

The establishment of apprenticeship courses for engineering graduates in such concerns as the Westinghouse Electric and Manufacturing Company, and in fact in nearly all fair-sized manufacturing concerns, is an acknowledgment by these concerns that the output of our engineering schools is unsatisfactory. If now a certain amount of the work required by these concerns after graduation can be done before, it is at once evident that the graduate will more nearly meet the requirements of his employers. It is the purpose of this paper to describe the system adopted by the School of Engineering of the University of Pittsburgh by means of which its gradu-

ates in the future will be better prepared to enter upon their work as engineers.

The adoption of a coöperative system, I believe, is a logical development of engineering education in the United States. When engineering schools were first established they were really schools of pure science. These proving unsatisfactory, as judged by the output, shops were taken into the schools and shop-work made a part of the curriculum. Now shop-work is, and probably always will be, an important agent for training the hand and eye. But when a school shop attempts to represent actual commercial conditions it is a total failure. The next step was to take the student to the shop, and at the same time to retain and add to those portions of the shop-work in school which have produced satisfactory results.

Because of the remarkable industrial environment of this school, it is especially well situated to apply the coöperative principle to the education of young men who are preparing to enter the engineering industries. The plan adopted is as follows:

The school year is divided into four terms of twelve weeks each, including the summer term. The freshman enters at the beginning of the fall term and remains in school during the whole of his freshman year. During the sophomore and junior years he spends one half of his time in the shop and one half in school, interchanging every three months. His entire senior year is spent in school.

We hope to accomplish three things by keeping the freshmen and seniors in school:

1. By means of lectures given by practicing engineers, visits of inspection, consultation, etc., the freshman obtain a fairly clear idea of the work expected of an engineer, and is better able to decide, not only whether or not he wishes to become an engineer, but also what kind of engineering work he wishes to pursue.

2. The faculty becomes acquainted with the students and consequently can eliminate the undesirable ones and at the

same time turn over to the manufacturer only those whom they think will make a success in engineering work.

3. The work of the senior year can be based not only upon the usual amount of theoretical and laboratory work, but also upon a year of practical work. It is evident that this arrangement will help the senior by making his work more interesting, giving him a better grasp of the subject, and increasing his interest in such subjects as economics, etc.

The school work under this plan consists of 128 weeks, which is 8 weeks longer than the course at the Massachusetts Institute of Technology. In addition to this, the student has twelve months of practical work in the space of four years. The school work is so arranged that successive groups of students furnish continuous service to the employer.

The work is conducted under actual commercial conditions. Thoroughly practical knowledge can be had only by actual work in the engineering industries and should be required as early as possible. Working side by side with other employees, students get an insight into labor conditions. Detailed observations of engineering work and the conduct of business, from the productive point of view, gained in the students' formative years, is an invaluable addition to knowledge gained from text-books and instructors. Although the university has made special arrangements with local industrial concerns and will coöperate with these concerns, in all possible ways, for the benefit of its engineering students, students are regarded as direct employees of the concerns. They serve for six working days each week, receive the pay of workingmen doing the same class of work, are required to observe the regulations of the company, and are subject to existing labor conditions and laws, including those pertaining to liability for accidents. This industrial practice is arranged, so far as feasible, to provide every student with an opportunity of working in the branch of engineering in which he is especially interested.

Each student reports to the proper instructor one evening

of each alternate week, for discussion of his practical work; at the end of the term, on presentation of a written report of his work and observations, he receives twenty credits.

Mr. S. M. Kintner, general manager for the National Electric Signaling Company, gives the manufacturer's point of view of the plan in the following paragraphs:

"To him it is a strictly business proposition. He does not undertake it from any motive of philanthropy. He expects a fair return in labor for the money that he expends. He does not expect to have the general discipline of his force interfered with and cannot, therefore, grant any special privileges. He offers the student an opportunity to see and study his works and methods while carrying on certain duties to which he has been assigned. He realizes that there will be a certain advertising feature, as the students will know of his product, will talk about it and possibly be instrumental in making sales of it as they go out into actual engineering work upon the completion of their course.

"The manufacturer sees still another advantage for himself in the plan—it puts him in touch with a number of young men who are just starting their training for lines of work in which he is interested as an employer. He is afforded an opportunity of looking over these men and picking out such of them as appear particularly good. He can then suggest certain lines of training that will fit them for his requirements, and he, in this way, has a chance of training up picked men for his force without expense to his company."

From the student's point of view, we hope to accomplish several things:

1. We believe that under the old system many students became engineers who would have made better preachers or lawyers. It seems fair to assume that if a man has had one or two practice periods in the shop or in field work, he will know for a certainty whether or not he is fitted to take up engineering work. If he does not know, his employer undoubtedly will.

2. He will come into contact with the ordinary laboring man, and will be afforded an excellent object lesson of the relative value of muscle and brains. It will undoubtedly lead him to a wholesome respect for labor and tend to give him a higher estimate of the value of brain training. He will be in a much better position to handle workmen later in life from his knowledge of the workman's ideas of his duties to his employer, etc.

3. In his university course everything is done for him; in his practice work he will find that he is doing things for everybody. He will find that seven o'clock means seven o'clock; and the discipline he gains by constant, regular and perisitent work will be of great value to him.

4. He will have an opportunity to study manufacturing concerns and organizations in their dealing with employees, in their methods of transmitting orders or technical information, in their methods of keeping records of their tools, materials, and finished product, in their method of keeping the time of the men and paying them.

5. He will make acquaintances and form friendships that will later be of great value to him in securing positions, in obtaining advice, etc. He will have a chance to "make good." Many men in school decide that they will go through school in the easiest possible way with the determination that as soon as they finish their course they will turn over a new leaf and make a fine record. The coöperative work will undoubtedly cause them to make good resolutions much earlier in life because the university will not retain students in the school of engineering who fail in their coöperative work.

6. Familiarity with actual engineering conditions will give the student confidence and a broader view of things. He will be able to secure more information from his instructors, and will be able to enter into class discussions.

I might mention a great many other ways in which the students will be benefitted by this coöperative work as for instance, the pay he receives, his ability to do things, his

independence as a wage earner, regular habits of study and work, increased efficiency, opportunities of employment upon completion of his course, etc., but it seems better to me to wait until we have facts upon which we can base certain conclusions, at which time I shall be glad to present to the Society further information concerning the cooperative work.

LOGARITHMIC DIAGRAMS AND THEIR USE IN LABORATORY WORK.

BY MR. H. A. GEHRING,

Department of the New York State Engineer, Albany, N. Y.

For several years I have had occasion to compute the flow of rivers from records kept at various dams. These records include the observed gage readings and the different lengths and heights of flashboards on both dam and spillway. At the time when I first took up this work, the method in use was to make out rating tables for all those conditions of flashboards which seemed to obtain most of the time, but there were also many conditions which obtained for short periods of time for which no tables were prepared. The discharge for these conditions was computed by formulæ. Obviously, where the crest conditions changed frequently, it was a long and tedious task to compute the discharge.

My attention was called to several articles in the *Engineering News* in which logarithmic diagrams were presented and it was suggested to me that I study into the principles on which such diagrams are constructed with a view to applying them to computations of the kind above given. Of the diagrams accordingly constructed one in particular has proved exceedingly practical and time-saving. This diagram gives the discharge over any length of crest for any head and for any coefficient.

During three years, while an instructor in hydraulics and mechanics at Cornell University, I had considerable experience in laboratory work. This experience has led me to conclude that logarithmic diagrams can be used to good advantage in the laboratory, and for the purpose of presenting this subject before this society, I have prepared the following paper which is divided into two parts.

PART 1. *Principles of Logarithmic Diagrams and the development of equations capable of being represented diagrammatically.*

This part appears in full in my article in the *Engineering Record* of January 15, 1910. It was originally intended to reprint it at this time, but upon further consideration it seemed inadvisable to do so because it is entirely of a theoretical nature, and because the above periodical is accessible to all who desire to investigate farther.

PART 2. *Suggestions regarding laboratory work with an illustration of the applicability of logarithmic diagrams.*

In the first place I believe firmly in the graphical representation of equations. Many data are conveniently put into tabular form, but where the data acquired can be stated in the form of an equation, their representation graphically is not only of practical accuracy and convenience, but it also stimulates in the student the excellent habit of graphical representation wherever possible.

The best method of presenting the subject of logarithmic diagrams to the student is in connection with a laboratory course. I am inclined to believe that too large a percentage of the time assigned to a laboratory course is spent in the computing room, and the adoption of means to facilitate the computations is highly desirable. Also as much of the computing as possible should be done in the laboratory itself and during the course of the experiment, leaving some period assigned to the computing room to be used in writing up a report on the work with a discussion of the results obtained.

I desire to lay great stress on the advisability of carrying on a certain amount of the computations abreast of the experiment. Too often in the computing room results are obtained which are obviously wrong. Much time is then wasted by the student in attempts to recall the circumstances of the experiment to see what might have caused such an error, but he cannot find the cause. It might have been an error in reading a gage, or the incorrect recording of the stop-watch, or an

unobserved leakage of a valve, or as is frequently the case, the man recording the data might have failed to hear and record accurately the information given to him. If all of the observed data can be utilized immediately to obtain the computed quantities finally desired, any error or discrepancy can be detected at the critical moment and rectified while the apparatus is still in position. Speaking from my own experience, I can state that the whole class is reasonably interested in the laboratory work while becoming familiar with the apparartus, and until a point is reached where each man has had an opportunity to read the different gages and to obtain the different observed quantities. Generally speaking, from that point on, the remainder of the work is done more or less mechanically and with a lagging interest which injects into the students a carelessness often evidenced by erroneous observations. Right here lies one of the strongest features of the system of plotting and computing the data as quickly as observed and recorded, as by so doing, carelessness is immediately detected and the guilty student apprehended. Hence this method yields both greater efficiency and greater interest, and indeed the latter alone need only be mentioned, for greater interest must of necessity imply a higher efficiency.

By way of illustration I will assume a class in experimental hydraulics and an experiment to determine the law of friction in a 4-inch pipe. I will also assume that the pipe is laid horizontally so that the loss of head read on the differential pressure gage may be attributed entirely to friction. For small velocities the water will flow into a pan placed on a scale and will be weighed, while for larger velocities a calibrated tank will be used to determine the total flow during the run. The quantities observed are either the total weight of water in pounds, W, or the total volume in cubic feet, Q_T, the length of the run in seconds, T, and the readings of both legs of the differential pressure gage. This actual observed loss of head I will designate by H_L and the loss in feet per thousand feet by H_f.

As soon as any run is completed and the observed data recorded by the recorder, the latter refers to the diagram shown in figure 1 and with a thread stretched taut obtains the velocity indicated by the observed total flow and the length of the run. This diagram should have been constructed by each student previous to the experiment and during an assigned computing period after a lecture by the instructor in charge. While a diagram can be made applicable to more than one diameter of pipe, it is advisable to require each student to construct a diagram for each size of pipe to be tested. This both gives him a better drill in and understanding of the diagrams, and also allows the diagram for each pipe to be drawn to a larger scale than would be convenient where too large a range of values is attempted on one diagram. The equations for this diagram are obtained as follows:

When the volume of water in cubic feet is observed and the diameter of the pipe is in inches,

$$Q_T = \tfrac{1}{144} \cdot \tfrac{1}{4} \pi d^2 TV,$$

which for $d = 4''$ becomes

$$Q_T = 0.087\ VT.$$

When the water is weighed, assuming the weight per cubic foot as 62.5 pounds, the resulting equation becomes

$$W = 5.45\ VT.$$

Ordinary logarithmic cross section paper should also be on hand in the laboratory, and as soon as the mean velocity is obtained as above described, it is plotted on this paper as an abscissa with the loss of head in feet per one thousand feet, H_F, as ordinate, computed from the observed loss, H_L. After a few points are thus plotted and the slope of the line well defined, any subsequent point which falls appreciably off the line immediately indicates an error somewhere. In this way some fault with the apparatus or gages is often detected which otherwise might have been overlooked and so have affected a series of runs, and this fact would not have become known

until perhaps a week later when the class met for computations. When the experimental work has been completed, not only has every student had an oportunity of learning the details of the experiment, but all the results obtained have already been plotted.

If no further experiments on other pipes are contemplated, the next assigned laboratory period should be devoted to computing. All the data obtained during the actual experiment should be in the possession of the instructor in charge between meetings of the class. In this interval he can examine the data at his leisure, and having weighed the plotted points, draw in the final line. The first part of the computing period should be devoted to a review of the experiment by the instructor and to clearing up all points of doubt. Each student should then be asked to plot the points on a sheet of ordinary logarithmic cross section paper and to reproduce the line as established by the instructor, obtaining its equation in the form,

$$H_f = mV^n.$$

When this has been done, a brief report should be written by each student and this submitted with his own plotting. The work done in the computing room ought not to require more than one hour of time.

I now wish to arrive *approximately* at the percentage of time saved through the adoption of the idea of plotting the data obtained during the course of the experiment itself and through the facilities of the logarithmic diagram used. In doing this, I will not count in the time devoted to the construction of the diagrams, as diagram No. 1 can be used for subsequent experiments and hence this time cannot properly be charged against the particular experiment in question.

Assuming three-hour laboratory sessions, there are three hours given to the experimental work and the collecting of data. When these data must be computed in the computing room at the next meeting of the class, my experience leads me to conclude that not less than three hours will be required

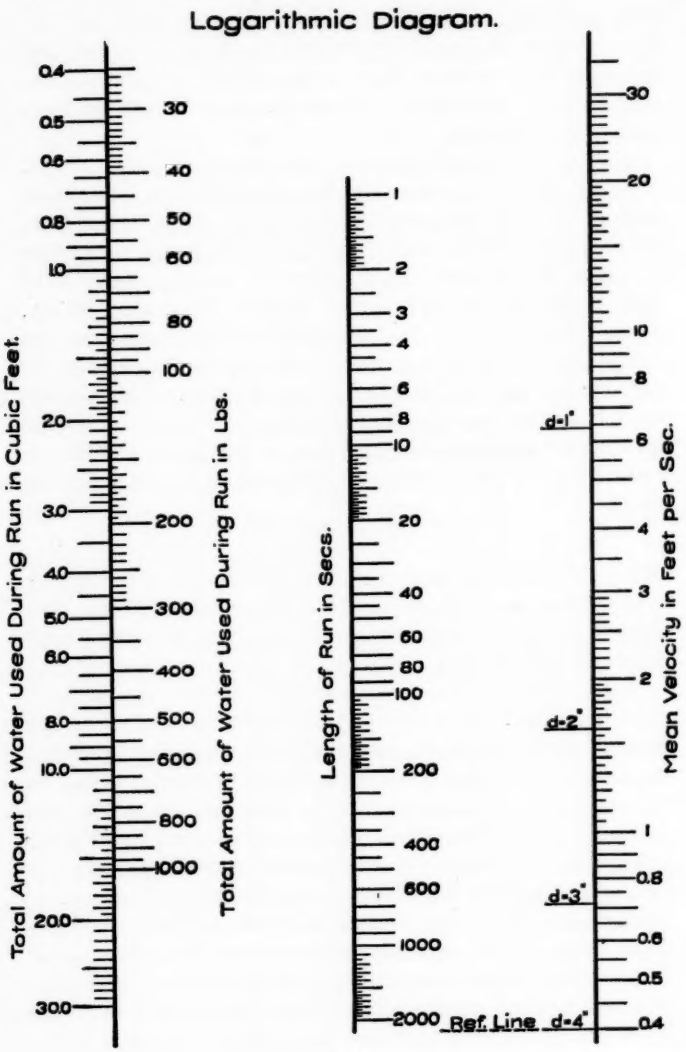
Logarithmic Diagram.
Total Amount of Water Used During Run in Cubic Feet.
0.4
0.5
0.6
0.8
1.0
2.0
3.0
4.0
5.0
6.0
8.0
10.0
20.0
30.0
Total Amount of Water Used During Run in Lbs.
30
40
50
60
80
100
200
300
400
500
600
800
1000
Length of Run in Secs.
1
2
3
4
6
8
10
20
40
60
80
100
200
400
600
1000
2000
Ref Line
d-1"
d-2"
d-3"
d-4"
Mean Velocity in Feet per Sec.
30
20
10
8
6
4
3
2
1
0.8
0.6
0.5
0.4

FIG. 1.

for this work when done by the use of tables and slide rule. I think that this is a very fair estimate, because an undue proportion of time is usually spent on points which are obviously wrong in an attempt to recall the circumstances of the experiment and so explain the wide discrepancies which it is not expedient to ignore. At the following meeting of the class, another hour devoted to a talk by the instructor and to writing up a report on the experiment may be sufficient to dispose of the entire subject; and hence I will allow a total of seven hours to the experiment and report and the obtaining of the equation representing the law of friction in the 4-inch pipe.

By the method of computing and plotting in the laboratory as above explained a total of 4 hours will suffice. Thus it will be noted that a saving of 3 hours has been effected, and this means a saving of 43 per cent. in time.

If experiments on other sizes of pipe are to follow, these should be performed at successive periods and the data observed and computed in the laboratory should be left with the instructor. Assuming that, in all, three sizes of pipe have been experimented on and three sets of plottings obtained, an inspection of the diagram, shown in Fig. 2, will make it apparent that if each line were drawn by itself without any reference to the other lines, each line might justly have a different slope n and coefficient m. To obtain uniformity of results which I think is advisable in an experiment like this, the instructor should give due consideration to the plotted data and by trial obtain one line which will answer for each of the three sets of points.

At the next meeting of the class for computations, where a series of pipes have been experimented on, I do not consider it necessary for each student to plot all the points for the experiments. If the laboratory work has been arranged to the best advantage, each student will have had an opportunity to take notes and plot some of the points. He should, however, equip himself with a sheet or logarithmic cross sec-

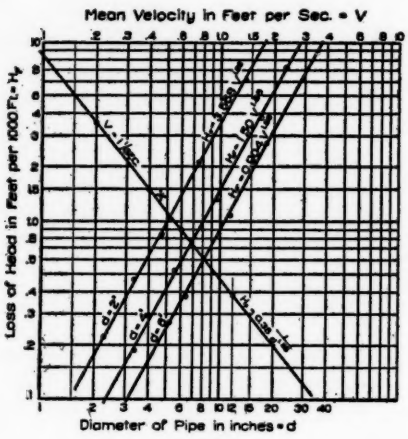

FIG. 2.

tion paper with four panels as shown in diagram No. 2 and on it reproduce the three lines as determined by the instructor. The resulting equations are as follows:

For the 2″ pipe, $H_f = 3.5684\ V^{1.86}$ (A)

For the 6″ pipe, $H_f = 0.9038\ V^{1.86}$ (C)

For the 4″ pipe, $H_f = 1.5003\ V^{1.86}$ (B)

Here the student's attention should be called to the fact that the exponent of V is the same for any size of pipe, and the question should be propounded "What will the coefficient reduce to when the diameter of the pipe is 1 foot or 12 inches?" To ascertain this, the student should note that for $V = 1$ foot per second,

$H_f = 3.5684$ when $d = 2''$,

also

$H_f = 0.9038$ when $d = 6''$.

and

$H_f = 1.5003$ when $d = 4''$,

Hence plotting these values of H_f as ordinates with the corresponding values of d as abscissæ, there results the line marked *A*. To determine its equation, it must be extended until it intersects the vertical line for $d = 12''$, when the value of H_f becomes 0.38. The slope of the line is negative since H_f decreases as d increases, and its value is 1.25. Hence the equation of this line becomes $H_f = 0.38 \frac{1}{d^{1.25}}$.

Combining this with the results of equation (A), (B) and (C) there is developed the general equation $H_f = 0.38 \frac{V^{1.86}}{d^{1.25}}$ which holds good for all sizes of pipe and for all velocities.

This equation is of standard form and is frequently seen in engineering literature, yet few students know how it is derived. I have no doubt but that in most laboratory courses in Experimental Hydraulics, not enough time is available for the course to permit of devoting to the subject of friction in pipes the time required to develop this equation. If, however, an appreciable saving of time can be effected by the adoption of means to facilitate the computation of data, it may become possible to develop this general equation, and it is surely advisable to do so.

Now to arrive at an approximate idea of the time saved through plotting the results during the course of the experiment itself and through the facilities of logarithmic diagrams, I will make the assumption that the equipment of the laboratory is such as to require a full three hour period for the experimental work on each of three pipes to be tested. If, then, 9 hours are devoted to obtaining observed data, so much data will be collected that say 6 hours will be required to make the computations in the computing room. Allowing 1 hour for a report on the experiment, there results a total of 16 hours devoted to the work. By carrying on the computations and the plotting abreast of the experiment, these 6 hours of computing can be saved; hence a total of 10 hours only will be necessary for the work; or a saving of 38 per cent. in time.

Too much weight must not be given to the actual percentages of time saved which I have deduced. The significance of these figures lies not in the fact that they show just what time can actually be saved by the methods above described, but in the fact that they do demonstrate that a sufficient saving of time can be effected to warrant the consideration of our engineering faculties.